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Serious Mental Illness, Glycemic Control, and Neighborhood Factors within an Urban Diabetes Cohort

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***Background and Hypothesis*: Serious mental illness (SMI) may compromise diabetes self-management. This study assessed the association between SMI and glycemic control, and explored sociodemographic predictors and geographic clustering of this outcome among patients with and without SMI. *Study Design*: We used electronic health record data for adult primary care patients with diabetes from 2 San Francisco health care delivery systems. The primary outcome was poor glycemic control (hemoglobin A1c >9.0%), which was modeled on SMI diagnosis status and sociodemographics. Geospatial analyses examined hotspots of poor glycemic control and neighborhood characteristics. *Study Results*: The study included 11 694 participants with diabetes, 21% with comorbid SMI, of whom 22% had a schizophrenia spectrum or bipolar disorder. Median age was 62 years; 52% were female and 79% were Asian, Black, or Hispanic. In adjusted models, having schizophrenia spectrum disorder or bipolar disorder was associated with greater risk for poor glycemic control (vs participants without SMI, adjusted relative risk [aRR] = 1.24; 95% confidence interval, 1.02, 1.49), but having broadly defined SMI was not. People with and without SMI had similar sociodemographic correlates of poor glycemic control including younger versus older age, Hispanic versus non-Hispanic White race/ethnicity, and English versus Chinese language preference. Hotspots for poor glycemic control were found in neighborhoods with more lower-income, Hispanic, and Black residents. *Conclusions*: Poor diabetes control was significantly related to having a schizophrenia spectrum or bipolar disorder, and to sociodemographic factors and neighborhood. Community-based mental health clinics in hotspots could be targets for implementation of diabetes management services.**

Key words: schizophrenia spectrum/bipolar disorder/diabetes mellitus/social determinants/geospatial analysis

Introduction

Serious mental illnesses (SMI; including schizophrenia spectrum, bipolar disorder, major depression, and autism spectrum disorders) are associated with 1.5–3 times higher risk for type 2 diabetes,[1,2] and with earlier death from cardiovascular disease (a common diabetes complication),[3,4] when comparing individuals to the general population or to those without SMI. Diabetes of any type can be difficult to manage alongside common challenges faced by people with SMI, which include poor access to physical or mental health care,[5] discrimination and stigma,[6,7] economic and social stressors,[8,9] obesogenic psychotropic medications,[10,11] behavioral risk factors,[12] and psychiatric or cognitive impairment.[13] Enhancing diabetes care quality, including achievement of target-range glycemia,[14,15] is critical for reducing risk for future diabetes complications and improving long-term health for people with SMI.

Past research has shown inconsistent associations between SMI and diabetes care quality and glycemic control. In some studies, people with SMI have similar or higher rates of glycemic monitoring, adherence to diabetes medications, and maintenance of target-range glycemia,[16–19] but other research has highlighted

disadvantages for people with SMI, including care gaps in diabetes screening[20,21] and in receipt of standard care to improve diabetes outcomes.[20–22] Outcomes may vary by specific psychiatric diagnosis, health care delivery system, and sociodemographic characteristics. Among people with SMI, suboptimal diabetes care quality has been documented for people with schizophrenia spectrum or bipolar disorder,[23] those with Medicaid insurance (a public program for lower-income US individuals),[20] and Hispanic or Black individuals,[19,21] but glycemic outcomes have not been closely examined in these subgroups. Due to historical and structural inequities leading to residential segregation, neighborhood-based analyses provide an additional lens to understand factors of glycemic control. Geospatial analyses of glycemic control can identify *hotspots* and *coldspots*[24] representing clusters of individuals with and without poor glycemic control and can highlight opportunities for intervention in the neighborhoods where individuals face the most risk.

In this retrospective cohort study of San Francisco Bay Area adults with diabetes receiving primary care services in 2 health care delivery systems of distinct types, we used electronic health record (EHR) data to assess the role of SMI (including schizophrenia spectrum or bipolar disorder, specifically), sociodemographics, and neighborhood in glycemic control. We focused on risk for having hemoglobin A1c (HbA1c) >9.0%, a commonly used health care quality threshold representing poor glycemic control.[25] We hypothesized that people living with SMI would have higher risk for poor glycemic control, when compared to those without SMI. We also identified geospatial hotspots and coldspots of poor glycemic control to illustrate a potential application of geospatial analysis to intervention planning for people with SMI and diabetes.

Methods

Study Population and Procedures

Study data came from 2 San Francisco health care delivery systems serving distinct populations. University of California San Francisco (UCSF) Health is a private, multi-hospital, multi-clinic academic health care delivery system serving patients with commercial (eg, employer based) insurance and public insurance (eg, Medicaid, Medicare). The multisite San Francisco Health Network (SFHN) is the largest safety net health care delivery system serving patients with public or no insurance in San Francisco. Patients were included if they had a diagnosis of diabetes mellitus, any type, documented in the EHR for ≥1 inpatient or ≥2 outpatient visit(s) January 1, 2015–June 30, 2017 (ICD-9-CM 249.x or 250.x; ICD-10-CM E08-E11 or E13); were age ≥18 years; and had a documented residential address in the San Francisco Bay Area that could be geocoded. The date of the first diabetes diagnosis in this 30-month "baseline" time window was the index date, to which a 24-month "follow-up" period was anchored. Given that many individuals may have been receiving medical care unrelated to their diabetes in the study health care delivery systems (particularly at UCSF, which serves as a specialty referral center), we excluded those without a primary care visit during the baseline and follow-up periods. We also excluded 9.0% of patients meeting the above criteria due to lack of a hemoglobin A1c test result during the follow-up period.

For UCSF patients, the most recent documented residential address on or prior to the index date was used. For SFHN patients, current address as of June 2019 was used as historical addresses were not available from the EHR. We geocoded patient residential addresses to latitude and longitude using ArcGIS Pro software with StreetMap Premium.[26]

This study was approved by the UCSF institutional review board, including waivers of informed consent and HIPAA authorization to access secondary EHR data. This study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.[27]

Measures

We classified participants as having or not having SMI based on diagnoses that were documented with health care visits (≥1 inpatient or ≥2 outpatient diagnoses during the 30-month baseline period) of schizophrenia, schizoaffective disorder, other psychotic disorder, bipolar disorder, major mood disorder, or autism spectrum disorder (see Supplementary figure S1 for diagnostic code list).

The primary study outcome was poor glycemic control, specifically HbA1c >9.0%, based on the most recent outpatient HbA1c laboratory result during the 24-month follow-up period. We did not include hospital-based results or glucose test results, as these might be more likely to reflect acute metabolic events rather than patients' typical level of glycemic control as captured by the more stable HbA1c measure.

We evaluated age category, gender, self-reported race/ethnicity, preferred language, health insurance type, and baseline health care utilization. We matched patients' geocoded residential addresses to census tracts based on the 2010 US Census and measured neighborhood socioeconomic status (nSES) at the census tract level using 2013–2017 5-year American Community Survey data on 7 related factors (eg, income, education).[28] We used quintiles of nSES based on all Bay Area census tracts.

We described neighborhoods based on zip code–level sociodemographic data from the UCSF Health Atlas website[29] and used a county directory to identify public mental health clinic locations where people with SMI could receive services.[30]

Analytic Approach

We first described characteristics of the study sample overall and by SMI diagnosis status. We tested for differences across groups using chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables.

In analyses examining associations between SMI and glycemic control, and correlates of this outcome stratified by SMI, we used 2 definitions: (1) a broad SMI definition (schizophrenia spectrum, bipolar, major depressive, or autism spectrum disorders) that has been used in prior studies,[19,21] and (2) a narrower definition including only schizophrenia spectrum or bipolar disorders. This narrower definition reflects a recent review finding variation in SMI diagnostic definitions, with schizophrenia and bipolar disorders being the most common diagnoses included in definitions of SMI.[31] Furthermore, people with schizophrenia spectrum or bipolar disorder may have worse diabetes care quality gaps, compared to people with major depression.[23] Additionally, people with schizophrenia spectrum and bipolar disorders are likely to be prescribed antipsychotic medications that are diabetogenic.[10]

We evaluated the risk of having poor glycemic control for those with SMI compared to those without SMI using modified Poisson regression models, with a robust error variance.[32] Serial adjustment was used hierarchically to evaluate associations accounting for different groupings of covariates based on theoretical considerations: first no adjustment; then, adjustment for demographics and health care delivery system; and finally, for the prior covariates, nSES, and insurance type. Models accounted for clustering by census tract when models adjusted for nSES.

In moderation analyses, we assessed interactions between SMI and each sociodemographic/health care delivery system characteristic in the prediction of poor glycemic control. These interactions were examined individually in separate modified Poisson regression models (1 model per interaction type) while accounting for all covariates. We present the relative risk (RR) estimates associated with each variable separately for those with and without SMI.

In sensitivity analyses, we re-estimated associations of SMI and sociodemographic predictors with the outcome stratified by health care delivery system in separate models to evaluate any distinct patterns per setting.

We used hotspot analysis to examine geospatial patterns of glycemic control in San Francisco. First, we confirmed that there was spatial clustering of this outcome based on the spatial autocorrelation tool in ArcGIS and global Moran's I index (I = 0.46; z-score = 313.62; P < .0001). To identify statistically significant spatial clusters of hotspots and coldspots of individuals with poor glycemic control, we used the Hot Spot Analysis tool in ArcGIS, which computes the Getis-Ord Gi* statistic. The Gi* statistic was used to compare the concentration of high (HbA1c >9.0%) and low (HbA1c ≤9.0%) values for a given "neighborhood" compared to the concentration observed across the full study area and calculate a z-score and P-value for each patient. We used a fixed distance band to define a "neighborhood" for each patient as the set of patients within 520 m (0.32 mi) based on maximum incremental spatial autocorrelation (z-score = 313.85; P < .001). A high positive z-score indicates a significant hotspot, that is, clustering of high values, whereas a low negative z-score indicates a significant coldspot, that is, clustering of low values. Hotspots and coldspots were not constricted to specific neighborhood boundaries, and these analyses did not adjust for patient- or neighborhood-level characteristics.

To assess correspondence of these clusters with neighborhood characteristics, we evaluated zip code–level sociodemographic data and plotted public mental health clinic locations.

Results

Descriptive Statistics

The sample included 11 694 adult primary care patients with diabetes; median age was 62 years; 52% were female and 79% were Asian, Black, or Hispanic (table 1). Overall, 2405 (21%) had comorbid SMI. Of these participants, 2013 (84%) had major depressive disorder and 523 (22%) had a schizophrenia spectrum or bipolar disorder. Patients with SMI significantly differed from those without SMI for all variables examined: for example, those with SMI were more likely to be under age 65 (67% vs 55%), female (56% vs 51%), have non-Asian race/ethnicity (77% vs 57%), receive care in the public health care delivery system (68% vs 63%), and reside in a neighborhood with low SES (59% vs 54% in lowest 2 quartiles). Participants tended to have regular HbA1c measurement during the 2-year follow-up period (SMI group mean = 3.6; no-SMI group mean = 3.4).

SMI, Sociodemographics, Health Care Delivery System Type, and Glycemic Control

A total of 1813 (16%) participants had poor glycemic control, including 426 (18%) of those with any SMI, 114 (22%) of those with a schizophrenia spectrum or bipolar disorder, and 1387 (15%) of those with no SMI (table 2). In unadjusted analyses, participants with any SMI were more likely to have poor glycemic control compared to those without SMI (RR = 1.19; 95% confidence interval [CI] = 1.07, 1.31), but this association was not statistically significant after adjusting for demographics and health care delivery system type (fully adjusted relative risk [aRR] = 1.04; 95% CI = 0.93, 1.16). When comparing participants with a schizophrenia spectrum or bipolar disorder to those with no SMI, there was a significant unadjusted association between these diagnoses and poor

Table 1. Participant Characteristics

Characteristic, no. (%) or median [interquartile range]	Serious mental illness (*N* = 2405)	No serious mental illness (*N* = 9289)	All (*N* = 11 694)	*P* value
Age, years	60 [52–67]	63 [54–71]	62 [54–70]	<.001
18–34	72 (3)	256 (3)	328 (3)	<.001
35–49	389 (16)	1233 (13)	1622 (14)	
50–64	1139 (47)	3660 (39)	4799 (41)	
≥65	805 (33)	4140 (45)	4945 (42)	
Gender				<.001
Female	1357 (56)	4766 (51)	6123 (52)	
Male	1048 (44)	4523 (49)	5571 (48)	
Race or ethnicity				<.001
Non-Hispanic (NH) White	527 (22)	1479 (16)	2006 (17)	
NH Asian/Pacific Islander	556 (23)	3953 (43)	4509 (39)	
NH Black/African-American	515 (21)	1266 (14)	1781 (15)	
Hispanic	704 (29)	2190 (24)	2894 (25)	
Other/Unknown	103 (4)	401 (4)	504 (4)	
Preferred language				<.001
English	1616 (67)	5189 (56)	6805 (58)	
Spanish	470 (20)	1623 (17)	2093 (18)	
Chinese	180 (7)	1567 (17)	1747 (15)	
Other	139 (6)	910 (10)	1049 (9)	
Insurance type				<.001
Public	1975 (82)	6189 (67)	8164 (70)	
Commercial	246 (10)	1600 (17)	1846 (16)	
Other/Unknown	184 (8)	1500 (16)	1684 (14)	
Neighborhood socioeconomic status quintile				<.001
Lowest, 1st	825 (34)	2874 (31)	3699 (32)	
2nd	596 (25)	2153 (23)	2749 (24)	
3rd	347 (14)	1573 (17)	1920 (16)	
4th	396 (16)	1642 (18)	2038 (17)	
Highest, 5th	241 (10)	1047 (11)	1288 (11)	
Health care delivery system type				<.001
Public, safety net	1625 (68)	5867 (63)	7492 (64)	
Private, academic	780 (32)	3422 (37)	4202 (36)	
Diabetes type				
Type 2	2294 (95)	8889 (96)	11 183 (96)	.32
Type 1 or other type	111 (5)	400 (4)	511 (4)	
Psychiatric disorder				
Schizophrenia spectrum or bipolar disorder, any	523 (22)	0 (0)	523 (4)	<.001
Schizophrenia or schizoaffective	282 (12)	0 (0)	282 (2)	<.001
Delusional	33 (1)	0 (0)	33 (0)	<.001
Other psychotic	147 (6)	0 (0)	147 (1)	<.001
Bipolar	172 (7)	0 (0)	172 (1)	<.001
Other disorder				
Major depressive	2013 (84)	0 (0)	2013 (17)	<.001
Autism spectrum	11 (0)	0 (0)	11 (0)	<.001
Baseline health care visits over 30 months				
Outpatient visits	23 [14–36]	15 [9–25]	17 [10–27]	<.001
Primary care visits	12 [8–18]	8 [5–12]	9 [5–13]	<.001
Any mental health	886 (37)	795 (9)	1681 (14)	<.001

glycemic control (RR = 1.46; 95% CI = 1.23, 1.73). This association was attenuated but remained statistically significant after adjusting for demographics and health care delivery system type (aRR = 1.25; 95% CI = 1.05, 1.48) and in the fully adjusted model (aRR = 1.24; 95% CI = 1.02, 1.49).

We then examined the associations between sociodemographic and health care delivery system factors and poor glycemic control, as moderated by SMI and adjusting for all covariates (table 3). Interaction *P* values were largely non-significant, indicating that participants with any SMI did not significantly differ from

Table 2. Relative Risk of Poor Glycemic Control Associated with Having Any Serious Mental Illness or Having a Schizophrenia Spectrum or Bipolar Disorder

	Any serious mental illness[a]			Schizophrenia spectrum or bipolar disorder[b]		
Covariate adjustment	RR	(95% CI)	*P* value	RR	(95% CI)	*P* value
None	1.19	(1.07, 1.31)	.001	1.46	(1.23, 1.73)	<.001
Demographics and health care delivery system[c]	1.05	(0.95, 1.16)	.33	1.25	(1.05, 1.48)	.01
Demographics, health care delivery system, and socioeconomic status[d]	1.04	(0.93, 1.16)	.54	1.24	(1.02, 1.49)	.03

A total of 1813 (16%) participants had poor glycemic control, including 426 (18%) of those with any serious mental illness, 114 (22%) of those with a schizophrenia spectrum or bipolar disorder, and 1387 (15%) of those with no serious mental illness.
[a]Models included $N = 2405$ with schizophrenia spectrum, bipolar, major depressive, or autism spectrum disorders ("serious mental illness") and $N = 9289$ with no serious mental illness.
[b]Models included $N = 523$ with schizophrenia spectrum or bipolar disorder and $N = 9289$ with no serious mental illness.
[c]Models adjusted for gender, age, race/ethnicity, preferred language, and health care delivery system.
[d]Models adjusted for gender, age, race/ethnicity, preferred language, health care delivery system, neighborhood socioeconomic status quintile, and insurance type.
RR, relative risk; CI, confidence interval.

those without SMI in the broad pattern of associations found between sociodemographic/health care delivery system variables and poor glycemic control. Within the no SMI group only, male sex and lower versus highest-quintile nSES were associated with greater risk of poor glycemic control, but these associations were attenuated in the any SMI group.

Similar to associations seen for the no SMI group, among those with any SMI, risk for poor glycemic control was significantly related to age <65 years (aRRs = 1.93–2.83 across younger age groups, compared to age ≥65 years) and to Hispanic ethnicity (aRR = 1.40; 95% CI = 1.05, 1.87; compared to non-Hispanic White), and was inversely related to Chinese language preference (aRR = 0.59; 95% CI = 0.37, 0.97; compared to English preference). The pattern of sociodemographic correlates of poor control was similar for participants with a schizophrenia spectrum or bipolar disorder, compared to the larger group with any SMI, except for an attenuated association between Hispanic ethnicity and poor control (Supplemental table S1).

In models stratified by health care delivery system, the overall pattern of associations between variables and glycemic control were broadly similar across health care delivery systems (Supplemental tables S2 and S3), though the RR associated with Hispanic ethnicity was attenuated for participants in the public health care delivery system and the inverse association between Chinese language and poor control was attenuated for participants in the private health care delivery system.

Geospatial Patterns of Glycemic Control for People with and without SMI

Hotspots (and coldspots) of poor glycemic control were similar for participants with any SMI compared to those without SMI (figures 1A and B). Hotspots emerged on Treasure Island and along a ribbon of neighborhoods on the east side of San Francisco, e.g., the Tenderloin and Visitacion Valley Districts. Smaller hotspot clusters also appeared in the Parkside/Outer and Inner Sunset Districts. Coldspot clusters were more diffuse throughout the city but were most prominent in some eastern districts (eg, Chinatown and Bayview Hunters Point) and western districts (eg, Outer Richmond). Relative to areas with coldspots, areas with hotspots tended to have lower nSES and more Black, Hispanic, and Spanish-speaking residents at the zip code level (Supplementary table S4). Public mental health clinic locations for adults are also shown in figure 1A, showing some areas with mental health clinic proximity, but little or no presence in several large hotspot clusters.

Discussion

Among adult primary care patients with diabetes, risk for having a key indicator of diabetes management challenges (HbA1c >9.0%) was positively related to having schizophrenia spectrum or bipolar disorder, but not to SMI when defined more broadly. The lack of significant association between a broadly defined measure of SMI and glycemic control may reflect the inclusion of a large subgroup with major depressive disorder. Past research has found that among patients with diabetes, those with depression had higher hemoglobin A1c over time than those without depression, but the difference between groups was small.[33] Depression diagnosis may be less predictive of glycemic control than is diabetes-specific distress.[34,35] Individuals with schizophrenia spectrum or bipolar disorder may have unique challenges that increase their risk for poor glycemic control, such as antipsychotic or mood-stabilizing medications that are associated with metabolic dysregulation.[10]

People with and without SMI, broadly defined, had similar sociodemographic predictors of risk for HbA1c

Table 3. Relative Risk of Poor Glycemic Control Associated with Sociodemographic Characteristics for Those with and without Serious Mental Illness

	Serious mental illness			No serious mental illness			
Variable	Relative risk	(95% CI)	*P* value	Relative risk	(95% CI)	*P* value	Interaction *P* value
Age (ref: ≥65 years)							
18–34	2.83	(1.87, 4.30)	<.001	2.45	(1.98, 3.04)	<.001	0.51
35–49	2.39	(1.80, 3.16)	<.001	2.40	(2.07, 2.79)	<.001	0.97
50–64	1.93	(1.50, 2.47)	<.001	1.65	(1.46, 1.87)	<.001	0.28
Male (ref: female)	1.07	(0.92, 1.25)	.36	1.20	(1.08, 1.32)	<.001	0.24
Race or ethnicity (ref: NH White)							
NH Asian/Pacific Islander	1.06	(0.77, 1.45)	.72	1.10	(0.92, 1.30)	.30	0.86
NH Black/African-American	1.10	(0.81, 1.50)	.52	1.14	(0.93, 1.40)	.20	0.86
Hispanic	1.40	(1.05, 1.87)	.02	1.40	(1.14, 1.73)	.001	0.99
Other/Unknown	1.01	(0.62, 1.66)	.96	1.14	(0.86, 1.51)	.36	0.70
Preferred language (ref: English)							
Spanish	1.10	(0.86, 1.40)	.47	1.15	(0.96, 1.37)	.14	0.73
Chinese	0.59	(0.37, 0.97)	.04	0.50	(0.41, 0.63)	<.001	0.54
Other/Unknown	0.98	(0.65, 1.47)	.91	0.73	(0.59, 0.90)	.003	0.20
Health care delivery system (ref: Private)							
Public	1.05	(0.84, 1.29)	.68	1.08	(0.93, 1.26)	.29	0.76
Insurance type (ref: commercial)							
Public	1.19	(0.87, 1.62)	.28	1.08	(0.92, 1.26)	.35	0.55
Other/unknown	0.87	(0.56, 1.36)	.55	1.12	(0.92, 1.35)	.25	0.30
Neighborhood SES (ref: highest quintile)							
1st	1.15	(0.85, 1.55)	.36	1.63	(1.33, 1.99)	<.001	0.06
2nd	0.98	(0.69, 1.37)	.89	1.34	(1.09, 1.65)	.01	0.13
3rd	0.90	(0.63, 1.29)	.57	1.30	(1.05, 1.62)	.02	0.08
4th	0.76	(0.53, 1.09)	.14	1.27	(1.01, 1.59)	.04	0.02

In estimating relative risk for poor glycemic control associated with each variable, modified Poisson regression models included interactions between serious mental illness (SMI) and each sociodemographic/health care delivery system variable (one model per SMI × variable interaction type), adjusting for gender, age, race/ethnicity, preferred language, health care delivery system, neighborhood income socioeconomic status quintile, and insurance type. Above, we present the relative risk estimates associated with each variable separately for those with and without SMI.
CI, confidence interval; NH, non-Hispanic; SES, socioeconomic status.

>9.0%, with young, middle-aged, and Hispanic individuals found to be at higher risk, and adults with Chinese language preference at lower risk. Past research has similarly found an association between younger age or Hispanic race/ethnicity and worse diabetes outcomes among people with and without SMI.[19,36] We previously found these associations in a private, integrated health care delivery system,[21] and the current study replicates these findings in a public and private health care delivery system. Geospatial analyses expanded on the risk factor findings: people with SMI and poor glycemic control were concentrated in neighborhoods with higher proportions of lower-income, Hispanic, and Black residents. Most of these specific neighborhoods (Treasure Island, Tenderloin, Mission, Bernal Heights, Oceanview/Merced/Ingleside, Excelsior, Bayview Hunters Point, Visitacion Valley) have a history of social disadvantage, including concentrated poverty, racial segregation, and disinvestment related to 1930s government-sponsored "redlining" which discouraged bank lending to residents; many of these neighborhoods rate poorly on health-related indicators such as food environment, community health resources, and life expectancy.[29,37,38]

As for protective factors, we found a significant inverse association between Chinese language preference (suggesting low acculturation) and poor glycemic control. This protective association, which held for individuals with and without SMI, conflicts with evidence suggesting that Asian-Americans are less likely to reach glycemic targets than White individuals, and that low acculturation is a risk factor for diabetes self-management difficulties.[39,40] In geospatial analyses, one of the largest glycemic control coldspots was found in Chinatown, which has a high proportion of Chinese- (often Cantonese-) speaking adults. In previous research on life expectancy, San Francisco Chinatown residents did not have greater premature death from chronic illness compared to other areas despite social disadvantage such as low median household income.[37] Future research is needed to understand possible unique protective factors in San Francisco's Chinatown and other Chinese-speaking communities.

Our finding that neighborhoods with poor glycemic control hotspots varied in their proximity to public mental health clinics is worthy of further study. Some hotspot neighborhoods for poor glycemic control among individuals with SMI had existing local public mental

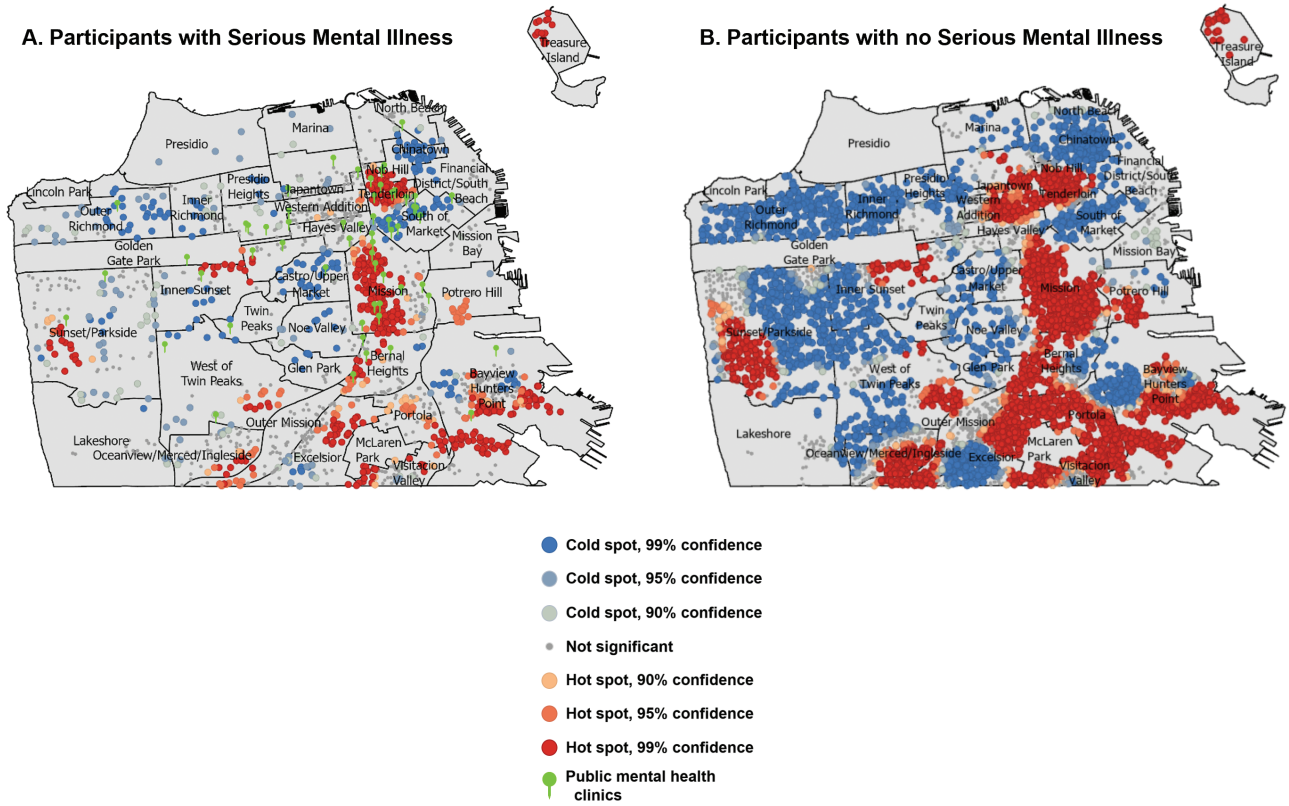

Fig. 1. Hotspots and coldspots of poor glycemic control in San Francisco.

health clinics, indicating an opportunity to integrate diabetes care services in these convenient locations. Many people with SMI feel more comfortable receiving medical care within mental health settings where they may already have established relationships with clinicians and face less stigma related to SMI.[41] For hotspot areas without public mental health clinics, public health administrators might consider partnering with primary care clinics to better meet the needs of people with comorbid SMI and diabetes in those areas.

Geospatial analyses illustrated that risk for poor glycemic control may be tied to place of residence. Potential neighborhood-based health determinants include economic deprivation, racial segregation, safety, and health-promoting characteristics of the built environment, such as walkability.[42–45] The current analysis focused on available data for neighborhood race/ethnicity and socioeconomic status, which often overlap in US cities.[46,47] Past research has demonstrated greater risk for negative metabolic health outcomes associated with geographic areas that are home to more low-income, Hispanic, and Black residents, who have historically faced barriers to health care access and economic opportunity.[48,49] In the current study, these neighborhood patterns were similar for subgroups with and without SMI. Future work is needed to understand additional place-based factors that may be unique to the population of people with SMI, as these patients face barriers to housing, employment, and social connection within communities that were unmeasured in the current study.

Limitations

Although study data were extracted from 2 major health care delivery systems, these were from 1 metropolitan region. Study findings should be replicated in other urban and non-urban regions, and in additional health care delivery settings. We excluded individuals who lacked 2 or more primary care visits during the large study window. Study findings may not generalize to individuals who are not engaged in health care or who are homeless—both groups likely to have diabetes self-management difficulties. The study did not include individual-level social determinant of health measures, which may be more relevant than neighborhood-level variables in areas with gentrification or high sociodemographic diversity. We did not have sufficient numbers of participants with schizophrenia spectrum or bipolar disorders to examine hotspots of poor glycemic control in this SMI subgroup. The study also did not examine other positive indicators of diabetes management that could be relevant for people with SMI, such as achievement of HbA1c at a lower threshold or control of other parameters such as cholesterol or blood pressure. The 9.0% threshold is higher than would be recommended for individual patients but is a commonly used diabetes care quality metric signifying

poor control at the population level; individuals' specific goals can vary based on factors including life expectancy, comorbidities, social support, and preferences.[50] We did not examine the role of psychiatric medications that can raise blood glucose, such as some antipsychotic medications, nor patterns in use of diabetes medications between individuals with and without SMI; these would be worthy directions for future work. It was not possible to measure diabetes duration from our EHR data. These limitations should be balanced with study strengths: we used EHR and geospatial data from a large population of socioeconomically diverse patients to examine sociodemographic and neighborhood-based factors for a key diabetes management indicator for people with comorbid SMI and diabetes.

Conclusions

Among San Francisco residents with comorbid diabetes and SMI, we found that having a schizophrenia spectrum or bipolar disorder, younger age, or Hispanic ethnicity were associated with greater risk for poor glycemic control. Hotspot analysis found greater concentrations of individuals with poor glycemic control in lower-socioeconomic status San Francisco neighborhoods with higher proportions of Hispanic, Spanish speaking, and Black residents, compared to neighborhoods with coldspots (clusters of individuals with HbA1c ≤9.0%). Some of these hotspot neighborhoods had community mental health clinics, suggesting an opportunity to integrate services supporting diabetes management within these settings as previously described.[51,52] The current study found similar sociodemographic risk factors and neighborhood clustering for poor glycemic control, regardless of whether individuals had or did not have SMI. These findings could be used by public health care delivery system administrators to target specific clinics and tailor services for a socioeconomically diverse patient population. Further investigation of place-based factors should be explored to further understand drivers of hotspot and coldspot clustering and to improve diabetes care for people with and without SMI.

Supplementary Material

Supplementary material is available at https://academic.oup.com/schizophreniabulletin/.

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